DEVELOPMENT OF A HABITAT ASSESSMENT AND PLANNING TOOL: A PROBLEM REFERENCE AND PROJECT WORKING PLAN

by

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May 1989

90-03841/

This publication is IWIFR-40

B.C. Ministry of Forests, Research Branch

B.C. Ministry of Environment, Wildlife Bulletin B-64

This project is jointly funded and directed by the
B.C. Ministries of Environment and Forests

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Citation:

Eng, M.A. and R.S. McNay. 1989. Development of a habitat assessment and planning tool: A problem reference and project working plan. Research, B.C. Ministry of Environment and B.C. Ministry of Forests. IWIFR-40. Victoria, B.C.

ACKNOWLEDGEMENTS

The need for maintaining spatial and temporal integrity in the process of assessing wildlife habitat has been recognized for years. A handful of biologists and managers in the Pacific Northwest and British Columbia have acted as catalysts in making that need a priority research topic, and a step forward in integrated management of timber and wildlife. We thank those individuals (Don Eastman, Rick Ellis, Rick Holthausen, Bruce Marcot, Brian Nyberg, Rick Page, and Hal Salwasser) for their support of the Habitat Assessment and Planning project and for their continued review of our progress. In addition, we would like to thank the members of the Integrated Wildlife - Intensive Forestry Research program Technical Working Group; the regional Fish and Wildlife staff in Nanaimo, Surrey, and Port Alberni; and the members of the Wildlife Branch Research and Development Section. Habitat Assessment and Planning is a project under the umbrella of the Integrated Wildlife - Intensive Forestry Research program, a co-operatively funded and administered program of the British Columbia Ministries of Environment and Forests and the University of British Columbia.

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1 PROBLEM REFERENCE

1.1 Planning for the Integrated Management of Timber, Deer and Elk

Habitat management is a commonly used method to achieve management objectives for wildlife populations. In British Columbia, however, wildlife managers do not have direct control over the timing and placement of habitat manipulations that result from extensive forestry. Foresters control extensive forestry activities, but are often not aware of the effects of those activities on wildlife habitat. The result is a lack of co-ordination and integration of the two management activities (forest and wildlife management), often leading to conflict. The specific impetus for this project is the long-standing indecision regarding the fate of old-growth forest deferrals set aside for black-tailed deer (Odocoileus hemionus columbianus) and Roosevelt elk (Cervus elaphus roosevelti). That issue has been the subject of intensive research for the past two decades (Bunnell 1985) and recent efforts have culminated in the production of a handbook for managing deer habitats (described by Nyberg and Janz 1989).

The attention given to black-tailed deer habitat is well justified because of the significance of this habitat to Crown revenues, employment, forest harvest, and social welfare. There are currently 50 000-100 000 ha of old-growth timber temporarily deferred from harvest. The estimated current net value of this timber is more than $50 million (B.C. Ministry of Environment and Ministry of Forests 1983). However, timber harvesting has already changed the characteristics of deer habitat dramatically. Much of Vancouver Island was once predominantly old-growth forests. It is now made up of predominantly even-aged stands of young conifers interspersed with patches of old growth. Timber harvesting affects more than 100 000 ha each year in British Columbia resulting in rapid changes to deer habitat.

The issue addressed by the Habitat Assessment and Planning (HAP) tool is not site-specific habitat management (that topic having been addressed earlier by Nyberg et al. 1989), but rather the planning for the integrated management over watershed-sized areas. Site-specific habitat management techniques can help alleviate resource management conflicts, but managers have little help in assessing the implications of their actions in the context of a watershed plan. A specific planning example might be: If a manager has enough funds to treat 300 ha of winter habitat silviculturally, on which sites (forest stands) are these funds best spent, and how does site selection relate to sites already treated or to the location and amount of other seasonal habitats? Planning for habitat management, therefore, not only requires a change in focus from the stand (10^2 ha) to a larger planning unit (10^3 ha) but also knowledge of other habitat specifications that are perhaps not explicit in the management problem. Shifting focus from site-specific habitat management techniques to planning

watershed management is difficult because much larger areas are involved and specific habitat problems must be examined in the context of overall habitat needs. For example, the proximity of spring forage habitat will weigh heavily on the ultimate value of any management to improve winter habitat quality. The latter difficulty is often referred to as area-based planning because each area will have unique spatial properties associated with it, and site-specific projects need to be scheduled to meet desired future conditions at the area scale.

Yet another problem arises when one considers that timber development and habitat management frequently occur at very different "operational" planning horizons. Forest engineers operate at a 2- to 5-year time frame, base activities on a forest stand, and describe timber value in terms of volume of merchantable wood per unit of land. Wildlife managers require longer time horizons (often 20 years or more), base their activities on both stands and watersheds, and describe wildlife value in terms of animal populations. The differences in planning horizons are largely a function of the fact that deer and elk must move to secure resources and trees do not. Trees are also easier to inventory than ungulates and depend on a unit of land that is fixed in space. Hence, forest vegetation is easier to map and area-based planning is less difficult than for the wildlife manager. How, then, can the planning for values be integrated when one value is both specific in time and space and the other is necessarily more global?

We use black-tailed deer, Roosevelt elk, and coastal forestry as our focus of problems in integrated planning, but the issue exists for most geographic areas (not just British Columbia) and most forest dwelling animals.

1.2 Previous Approached to Planning

Two planning approaches have been used in the past to integrate forest and wildlife management in British Columbia. One of them, the "referral system," is used predominantly. In it, responsibility for planning and conducting logging and silviculture is delegated, in most coastal areas, to forest companies holding area-based cutting rights. Government agencies led by the B.C. Ministry of Forests (MOF) approve and monitor company programs. Companies do not have the ultimate responsibility for wildlife, so logging plans are initially developed without reference to deer and elk needs. Company plans, are jointly submitted to both timber (MOF) and non-timber resource agencies (B.C. Ministry of Environment [MOE] and Department of Fisheries and Oceans [DFO]) through the Letter of Understanding referral process.

The referral system by nature discourages incorporation of wildlife habitat concerns early in the planning process and puts

MOE in a less than desirable reactive position. The process stipulates a short-term planning framework (usually with a 5-year planning horizon) and forces wildlife managers to focus on a stand-by-stand scale. Both are inappropriate for most wildlife habitat planning. As a result, wildlife managers are currently in a poor position to deal with the long-term or large-scale implications of decisions made through the referral process - particularly when several tenures and forest companies occur within the same watershed. Hence, short-term logging development is favoured rather than long-term timber/wildlife habitat planning.

The "interdisciplinary team" approach is occasionally used for high-value watersheds in the province. Under this system, the lead agency (normally MOF) brings together a group of its own experts and others to formulate a set of joint resource objectives and develop an integrated resource plan. Although this approach is more conducive to developing a long-term integrated plan, it requires many specialists on each team and can consume much staff time. The latter deterrents preclude extensive use of the interdisciplinary team approach in coastal areas.

The following case example illustrates the current problems in planning for integrated management of ungulates and timber in coastal British Columbia. The case shows the use of the interdisciplinary team approach to preparing a plan for the Artlish watershed on northern Vancouver Island. The goal was to develop a Local Resource Use Plan to guide multiple use development on the 15 000 ha watershed. Involved were three licensees; two different forms of tenures within two different forest districts; and MOF, MOE, and DFO.

The capability of the land to support both deer and elk was determined by biophysical mapping. Physiographic and biogeoclimatic units were used to interpret and map ungulate winter habitats and to delineate potential for high quality forage production sites for spring and summer habitats. Forest cover and logging operability maps were compared (by a manual overlay method) with wildlife capability maps to identify conflict areas. The map comparison also formed the basis for assessing tradeoffs and for planning long-term logging development, given the constraints of tenure type, annual cut requirements, and wildlife habitat values.

A 20-year logging plan was developed based on the above considerations. It incorporated considerations for deferral from harvest of winter habitats, replacement of old-growth stands with managed second growth, and the spatial and temporal patterns of forage and cover on the seasonal ranges.

At least three major difficulties negatively affected the Artlish exercise. The first involved a simple limitation of staff and time available for the planning approach. The overall procedure took several years of dedicated but often interrupted,

work, a significant amount of which was devoted to constructing maps. The same biophysical maps could now be generated by computer if topographic, biogeoclimatic, and forest cover maps were available in digital form.

Second, it was difficult (and mostly impossible) to schedule and project forest management over a 20-year period while simultaneously evaluating forestry's impact on habitat values - particularly since habitat values depend partially on the spatial arrangement of specific features such as food and cover, which occur in unique combinations at each point on the map sheet and change with each forest harvesting operation.

Third, written records of the decisions made now appear to be inadequate for updating, monitoring, evaluating, and revising the process and its effects and results. Staff changes make this situation even worse.

Other problems may yet result from the inability to monitor the development in the Artlish, to evaluate the decisions that were made. Few records are available of changes made to the plan, such as those in forest development plans and tenure types.

1.3 Alternatives to Current Methods of Integrating Timber and Wildlife Planning

Increased knowledge of the interaction between deer and forest management activities, coupled with communication between forest and wildlife managers, would help ensure that deer habitat requirements were included in the referral process early (Nyberg et al. 1989). Even so, the relatively fast pace and diverse spatial nature of forest management activities will dictate the need for automated, analytical tools before long-term planning can happen adequately and frequently. Such analytical tools would:

- enable the assessment of watershed-wide impacts resulting from site-specific management prescriptions;
- help reduce the need for excessive staff inputs;
- allow pictorial or textual records of decisions to be maintained; and
- help managers respond to information requests quickly and efficiently.

Regardless which type of analytical tool is developed, there is a risk that it will not be acceptable to all users (forest and wildlife managers as well as planners). Hence, to counter that tendency, it would be useful to have all users involved intimately with the construction of such a tool.

Projecting and evaluating habitat changes is a time-consuming and repetitive task. The potential to generate large quantities

of data makes the chore ideal for computers. Nevertheless, hardware and software limitations are a concern. The tool should function on available computer technology, or at least on technology that will be widely available in the near future. The aim to accommodate hardware and software limitations must be balanced against the risk of constructing a tool that is too simple.

Lastly, there is a risk of not proceeding with the development of any new analytical tool and remaining with the status quo. In that case it would be unlikely that integrated management could ever be well planned, largely due to incompatible planning horizons for two vastly different values: timber and deer.

2 THE INSTITUTIONAL FRAMEWORK FOR THE HABITAT ASSESSMENT AND PLANNING TOOL

The general objective of the Habitat Assessment and Planning (HAP) tool development project is to develop planning aids to translate research knowledge about the habitat relationships of black-tailed deer and Roosevelt elk on Vancouver Island and the south coast of British Columbia into effective tools for wildlife and forestry managers. More specifically, the HAP tool will be a series of microcomputer-based models that will allow planners to consider spatial and temporal aspects of ungulate habitat in the development of harvest schedules, habitat plans, and operational forestry plans. The "ideal" HAP tool would allow planners to:

- assess the quality of deer and elk habitat and the impacts of proposed forestry plans and activities on that habitat;
- provide information to recommend changes in plans that will minimize impact and increase the benefit of forestry on deer and elk habitat;
- identify the risks of pursuing management actions with uncertain effects and, where possible, identify the data required to reduce the uncertainty;
- help assess priorities for, and the cost effectiveness of, habitat management (enhancement) projects; and
- help document the rationale for decisions that affect deer and elk habitat.

The HAP tool will be a framework for integrating wildlife habitat planning concerns into forest planning in the province. In its initial form, the HAP tool will be applicable to black-tailed deer and Roosevelt elk on Vancouver Island and the south coast of British Columbia However, it should be viewed as a prototype of a more generally applicable tool that could be used throughout the province for any wildlife species.

One of the basic concepts underlying the HAP tool is that "game abundance should increase in situations where various types of food and cover come together" (Leopold 1933). Attempts have been made to incorporate this concept of habitat interspersion into wildlife planning through the use of "interspersion indices" of varying complexity (Hienen and Cross 1983; O'Niell et al. 1988). These indices, however, fail to represent wildlife habitat adequately because they "add up" interspersion over large areas and thus fail to represent the relationship among individual habitat polygons (stands). Adequate representation of spatial interspersion is possible only if habitat data are processed so as to retain its spatial integrity. This was not feasible until computerized map analysis (geographic information systems [GIS]) was developed. Useable microcomputer-based GIS software has only recently become available and GIS use in natural resource management is still in its infancy (Coughlan and Olliff 1988). However, some reported results show the potential utility of GIS

for dealing with the analysis of spatial interspersion of habitats (Lyon et al. 1987).

The HAP tool will represent a notable technological advance for both resource management (i.e., integrating forestry and wildlife concerns [Nyberg et al. 1989]) and for computer science (i.e., GIS [Coughlan and Olliff 1988] and expert systems [Marcot 1986]). However, the expectations of potential users and managers must be tempered by the very real limitations that may exist as a result of inadequacies in data availability and understanding of natural systems. Gaps in information and understanding may occur at various levels. For example:

- Government polices may not be comprehensive or supportive enough (e.g., the MOE deer habitat/population objectives for individual watersheds or planning units may be unclear).

- Various models required by the HAP tool (particularly in the fields of forestry and economics) may not be available (e.g., models of stand succession and growth for years 1 to 20 after harvesting may be lacking).

- Specific data may be unavailable and or the nature of specific relationships may not be quantified (e.g., the minimum size of an effective thermal cover area may be unknown, or whether the size varies with snow zone).

It is beyond the scope of this project to "fill" all of the existing gaps in information and understanding. Therefore, the "ideal" HAP tool and one that can be constructed at this time will be different.

The approach will be to develop a framework for the "ideal" HAP tool. Component parts of the framework will then be developed to the level of detail that is possible given the technological constraints outlined above, and administrative constraints (manpower, budget, and schedule). The terms of reference specify that an operational tool of some utility must be delivered by March 31, 1991. The delivered HAP tool will be functionally complete, though it will make use of "expert opinion" where policies or data are lacking and "manual methods" where models are lacking. The tool will be developed with an "open ended" architecture, so that it can incorporate new data and models as they become available.

The HAP tool will be developed without significant consideration of the current methods of planning, particularly at the strategic level, within the British Columbia government. Current planning methods are in a state of flux as new planning procedures are being developed (e.g., Analysis Framework for Integrated Resource Management [AFIRM]). In addition, the current public/political controversy over the consideration of integrated resource management in forestry planning may change the way in

which public service and private sector foresters plan in the future. The HAP tool must be able to fit into the strategic forest planning system that is eventually developed, but development of the tool should not be limited by what that planning system may look like. However, existing levels of planning and data sources used in planning will be considered during the development of the HAP tool.

2.1 User Profile

The HAP tool will be of value to three groups of professionals involved in forest planning. These groups approach forest planning from different perspectives, and they have different and largely non-overlapping objectives and duties with regard to forest planning:

1. Regional Habitat Protection Biologists and Technicians within the MOE aim to minimize the impact of forestry activities on wildlife habitat. Their duties are primarily to recommend changes to operational forestry plans, prepared by public service and private sector foresters, so that forestry operations will have minimal adverse impacts on wildlife and fisheries habitat.

2. Regional Foresters and District Foresters within MOF aim to ensure that MOF policy, in terms of annual allowable cut (AAC), is met by forest licence operators. Their duties are to respond to operational forestry plans to ensure that the AAC will be met and that other resource values, including wildlife, will not be degraded. In addition, they are responsible for preparing "small business" operational forestry plans for some areas within Timber Supply Areas (TSA's) and Tree Farm Licences (TFL's).

3. Divisional forest planners within the forest industry aim primarily to minimize the cost of timber harvesting. Their duties are to prepare operational forestry plans that will meet this objective and be acceptable to MOE, MOF, and DFO.

In addition to the differences in objectives and duties, these groups have very different backgrounds, job experience, computer experience, facilities, and resources.

The user group with the greatest immediate need for the HAP tool is the Habitat Protection Biologists and Technicians. This is a result of the direct mandate of the MOE to manage wildlife resources. In addition, these users are the most knowledgeable about habitat requirements and forestry impacts on habitat. They will, therefore, be most able to identify needs for improvement in the HAP tool. For these reasons, the HAP tool will be initially designed with this user group in mind, although the needs and

capabilities of the other potential user groups will be considered as well.

The Habitat Protection Section of the Vancouver Island Region of the MOE currently consists of two Habitat Protection Biologists, stationed in Nanaimo, and four Habitat Protection Technicians in three locations: Nanaimo, Campbell River, and Port Alberni. The Habitat Protection Section responsible for the south coast of British Columbia consists of two Habitat Protection Technicians, stationed in Surrey, and one Habitat Protection technician in each of Surrey and Chilliwack. This group has considerable training and experience in dealing with deer and elk habitat issues using "manual" methods and analog maps. However, successful extension of the HAP tool to this group will require a careful implementation strategy and extensive staff training in the use of microcomputers and GIS.

2.3 Task Profile

The final HAP tool will be used to support a variety of tasks performed by all three potential user groups. These tasks include the development of 5- and 20-year plans for TSA's and TFL's and for the development of Local Resource Use Plans and small business plans. Eventually forest planning should progress to the point where rotation age plans are created according to an area-based planning method. Initial development of the HAP tool will concentrate on aiding the task of responding to 5-year "operational" plans submitted to the MOE by forestry companies or developed in conjunction with MOF. This task has been chosen because it represents a major portion of the work load for the "prototype" user group (Habitat Protection Biologists and Technicians).

Five-year plans are prepared by forestry companies and the Forest Service on an annual or bi-annual basis and they are submitted to MOE and DFO for review and approval. The plans consist of proposals for stands to be harvested in each year of the 5-year plan, approximate road layouts, and lists of environmental constraints that will be adhered to. Because of the complex nature of land tenure in British Columbia numerous different 5-year plans could be submitted for a single watershed. A single watershed may encompass several TFL's, TSA's or Forest Licences (FL's). A complicating factor is the "Small Business Program" that operates on TSA's, TFL's and FL's.

The Habitat Protection Biologists and Technicians are responsible for reviewing the plans and suggesting changes to the areas and schedules of cutting so that the impact on wildlife habitat is minimized. This task is extremely complex and requires a good understanding of species habitat requirements, forest successional patterns, and local conditions. Recommendations frequently include:

- long-term deferral of logging of old-growth stands that represent high quality winter range for ungulates;
- short-term deferral of old-growth stands that represent potential foraging areas and potential security or thermal cover;
- changes in the scheduling of spacing and thinning operations to enhance the production of desired cover or forage attributes; and
- changes to road layouts and logging methods to minimize impacts on wildlife.

The task of responding to 5-year plans represents a major portion of the work load of Habitat Protection Technicians on Vancouver Island and the south coast. Plans are normally submitted early in the calendar year and Habitat Protection staff are expected to respond to them before the end of March. As a result, technicians may have up to 10 plans to respond to at any one time. The response to each plan can take from 20 to 120 hours to prepare, depending on the complexity of the plan, the size of the planning area, and the sensitivity of wildlife issues in the area.

Although responding to TFL plans is an interesting and complex task, user satisfaction with the current method is low because:

- much of the task is menial and repetitive, involving the comparison of new and old plans to detect changes in the plans from year to year, and the "processing and filing" of responses to plans;
- current methodology relies heavily on site-specific knowledge, but very little time is available to obtain site-specific information if it does not already exist;
- the extreme complexity of the spatial and temporal interactions of habitat quality are very difficult to assess manually, which often results in errors and overly conservative recommendations; and
- the task is so time consuming that adequate time to respond to other kinds of referrals (municipal, industrial, etc.) is not available.

Use of the HAP tool will help alleviate these problems by:

- automating many of the menial aspects of the tasks;
- identifying a small subset of the total area where site-specific knowledge is critical;
- reducing the spatial and temporal complexity by modelling the spatial and temporal aspects of habitat quality; and
- reducing the total time required to prepare a response and so allowing more time for other duties.

3 GENERALIZED HAP TOOL STRUCTURE

3.1 Underlying Concepts

The development of the HAP tool structure that is presented here was based on several underlying concepts. These concepts are described below.

3.1.1 The planning unit

The HAP tool must be applied within some circumscribed planning unit. Regional forestry plans are often prepared for entire TFL's or TSA's. This normally represents too large an area to be an effective planning unit for wildlife habitat because of the variability in conditions throughout the area. In addition, the TFL boundaries are set according to administrative considerations, and the habitat planning unit should be set according to environmental considerations. Operational forestry plans, on the other hand, are designed on a stand-by-stand basis and hence are too small to incorporate the habitat requirements of even a single ungulate. Ideally, the habitat planning unit would relate to the population characteristics of the species in question, which for deer is most likely to be the watershed. Biological evidence for the planning unit definition is a subject of research on a related project (McNay and Morgan 1989). An effective planning unit could be defined using some combination of watershed boundaries and the boundary between the low snow zone and the moderate/deep snow zone (Nyberg and Janz 1989).

3.1.2 Scale and resolution of data

To a large extent, the time scale considered is dictated by the forest planning procedures. Operational plans are developed for 5-year periods and significant changes in wildlife habitat resulting from forest regrowth probably can not be detected over a shorter time than this. The temporal extent of the modelling process would ideally include at least one full rotation for the managed forest.

There are currently many questions and few answers about what level of detail in the data is required to model deer and elk habitat adequately. Are ecosystematic association maps required or will forest cover maps suffice? Can 1:250 000 scale topographic maps be used to represent the required aspect and elevation variables, or is 1:20 000 scale data needed? These questions and many like them can only be answered through processes of management objective clarification , and of data analysis and model creation and verification. It is unlikely that there will be a single answer to many of the questions involving data resolution. Data requirements will vary with the specific nature of management questions and the geographical area of interest. Use of the HAP tool will probably involve an iterative approach in which managers

try to answer the questions with available data. The HAP tool will then generate a list of data requirements to answer the question.

3.1.3 Decision aids vs decision making

The HAP tool will provide information to managers which they can use to make decisions about operational forestry plans. It will not make decisions. Developing a "decision-making" tool would require "rules" about biology and forestry that we can not presently develop. In addition, input from managers about the types of management actions will allow for adaptive management (Walters 1986) procedures to be developed and incorporated. This will eventually lead to an improvement in the way in which forests are managed.

3.1.4 Reductionism vs holism and Occam's razor

Because the system we are attempting to model is extremely complex it might be assumed that an adequate model of the system must also be complex. This assumption often leads to a "reductionistic" modelling philosophy; that is, "a whole can be understood completely if you understand its parts and the nature of their sum" (Hofstadter 1979). In the past, this approach has been successful for modelling simple systems uninfluenced by history, particularly in the field of physics. However, we believe that the use of a reductionistic modelling approach for ecological systems would likely have limited success. The reason is that, for complex systems, "the whole is greater than the sum of its parts" (Hofstadter 1979). This alternative world view, known as holism, requires a "top down" approach to modelling in which the desired output of the model is identified and the model includes only the necessary components of the system required to obtain that output.

The debate over the correctness or validity of the reductionist versus the holist world views will probably never be solved because neither view is wrong nor right (Hofstadter 1979). However, from a pragmatic point of view, modelling should be done on the basis of Occam's razor, that is, "it is vain to do with more what can be done with fewer" (Dunbar 1980). This approach is to build the simplest model that appears to produce useful and realistic results. It is largely holistic, and can be accomplished with the development of a model in which an expert specifies those aspects of the system which he believes are important for arriving at the desired model output.

The "Occam's razor" approach is advantageous for four reasons:

1. The models are simple and can be clearly understood and "believed" by managers with expertise similar to that of the model developers.

2. Model inputs are simple to obtain because they are frequently the opinions of experts.
3. The models can be developed quickly and inexpensively.
4. The models live or die based on their management success.

3.2 General Description of Components

The complete framework for the HAP tool currently consists of three component parts:

1. a regional priorities model;
2. a watershed assessment model; and
3. a management options model.

Each model will have separate inputs and outputs. The outputs of the three models will be linked as inputs to other models so that the framework will operate in an integrated and iterative fashion (Fig. 1). The regional priorities model will be used to obtain a ranking of planning units (watersheds) for habitat management. For each high priority planning unit, the watershed assessment model would be used to evaluate the proposed forestry scenarios and specify the requirements for habitat management. If no requirements are identified, the process returns to the regional priorities model to obtain a new planning unit for assessment. If requirements are identified, the management options model is used to obtain a relative cost/benefit ratio for the proposed management action. If a poor cost/benefit ratio results, the process returns to the regional priorities model to obtain a new planning unit for assessment.

The regional priorities model will be designed to answer many of the questions that managers have about where, in a regional context, management efforts should be directed. An example of such a question is, "Where are deer management values of low priority such that little or no effort is required for spacing/thinning to provide supplemental forage production, thermal cover or winter range?"[1] Although the model will be based on an expert system, users will still require substantial knowledge about the geographical area and species of interest to produce useful and realistic results. The model would require the user to answer a series of specific questions and it may obtain input from, or assist the user in providing input, through small scale map based data and government or industry policy information. Outputs would include a ranking of planning units (watersheds) needing a detailed assessment of habitat quality. Additional output would include records of the reasons why the ranking occurred, so that future

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[1] McDougall, I. 1987. Phase II - problem analysis for second growth habitat: an overview for H.A.P. (Habitat Analysis Procedure). B.C. Min. Environ., Nanaimo, B.C. Memo. 5 p.

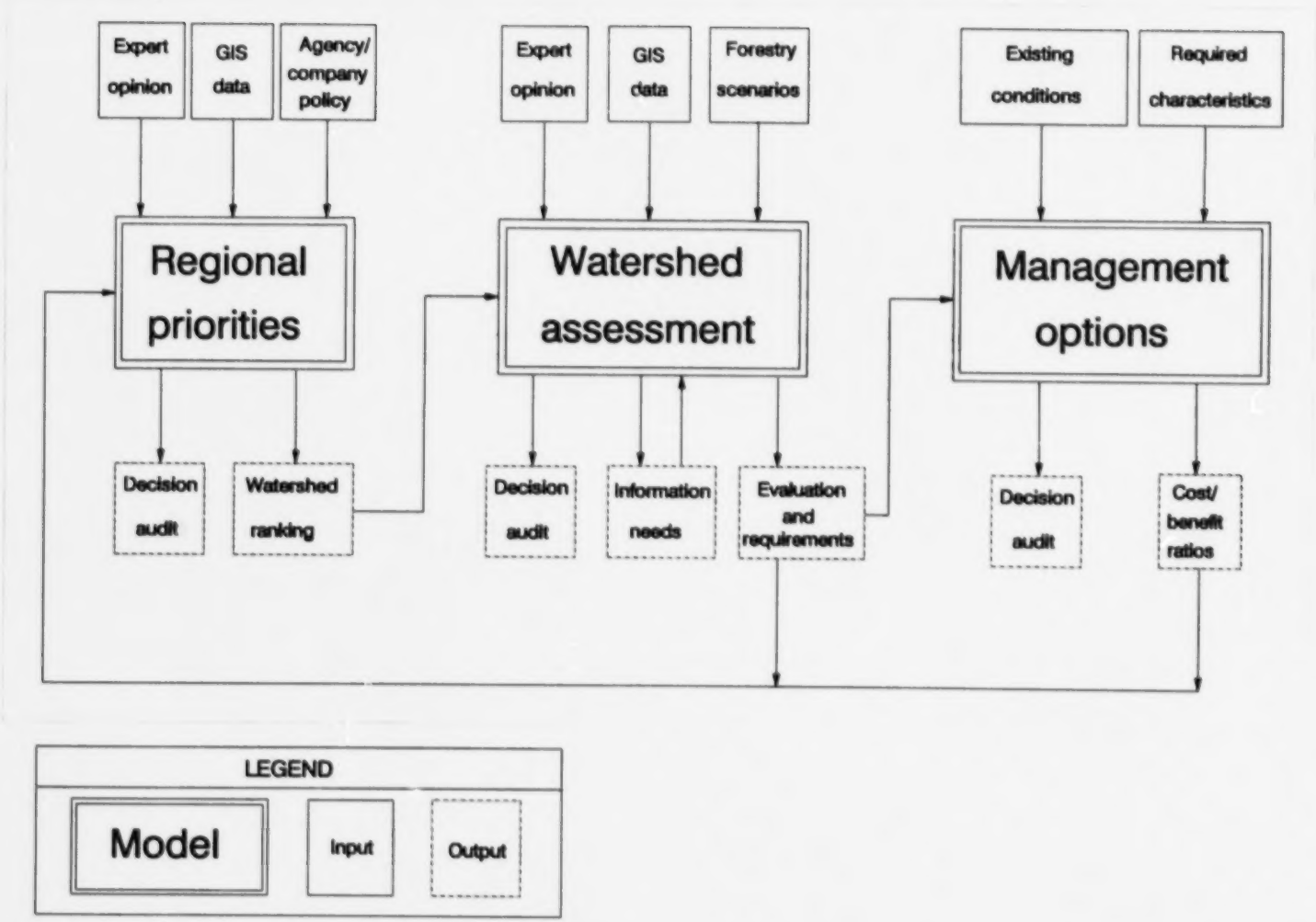

FIGURE 1. Conceptual framework for habitat assessment and planning.

managers could evaluate the decisions.

The watershed assessment model forms the core of the HAP tool. It should "help in resolving habitat management decisions over a watershed-sized area and through predetermined time steps" (Harcombe and Baker 1987). The model will be GIS-based and rule-driven. It will allow the assessment of the habitat suitability of watersheds at a single time. To include the temporal aspect of the assessment the vegetation succession of forested land would be projected through time, and the watershed assessment redone at predetermined time intervals. Input to the model would include large-scale GIS-based data on the present conditions of the landscape in the watershed, proposed operational forestry plans, and long-term forestry objectives for the watershed. Model outputs would be of four types:

1. Data inadequacy: an identification of locations (stands) in the watershed where the available data are not sufficient to allow a reliable assessment of the present or future habitat conditions in the watershed.
2. Sensitive stands: identification of locations (stands) in the watershed where small changes in stand characteristics would result in large changes in habitat suitability.
3. Future forecasts: map-based, graphic and tabular reports on the changes in habitat suitability within the watershed, through time, that will assist managers in assessing the impact of proposed forestry plans and in making recommendations to minimize those impacts.
4. Documentation: decision audit mechanisms that would record the results of the watershed (habitat suitability) assessment and the subsequent management decisions made by managers so that future managers could evaluate those decisions. The decision audit mechanism would also assist Habitat Protection staff in their day-to-day duties (namely, processing and filing of plan referrals).

The management options model would determine the most appropriate methods of producing the habitat requirements identified by the watershed assessment model. In addition, the management options model should include "cost/benefit analyses (that) could lead to the understanding of the future implications determined by site-specific and time-specific management actions" (Harcombe and Baker 1987). The model would use as input the habitat requirements, determined by the watershed assessment model, and the existing conditions and required characteristics of the stands in question. Model outputs would be relative cost/benefit ratios of the site specific management actions. The cost/benefit ratios could result in a reapplication of the regional priorities model if it is determined that poor ratios result, lowering the regional priority for a particular watershed.

3.3 Regional Priorities Model

Development of the regional priorities model assumes that a basic "net down" of areas of little or no concern will be conducted at a strategic planning level outside the HAP tool. The regional priorities model will then be applied within the remaining areas.

A prototype regional priorities model has been constructed (McNay et al. 1987; McNay and Page 1988). This model is an expert system-based decision hierarchy that attempts to mimic the thought processes of habitat biologists in solving the problem of where to direct habitat management efforts for black-tailed deer or Roosevelt elk. The model attempts to find the limiting factor among three major questions:

1. Are deer or elk a sensitive management issue from the point of view of predation, societal demand, etc.?
2. Is the topography capable of supporting deer or elk?
3. Is the current habitat suitability comparable to the topographic capability?

Each of these questions is asked by a series of specific sub-questions. The manager may ignore some of the specific factors (such as predation) in the model, but the basic logical structure of the decision-making process is fixed.

The prototype regional priorities model will be improved and refined during the course of the HAP tool development project in several ways:

- The original model was programmed in a relatively inflexible expert system that required specific questions to be asked and answered using one question format. The refined model will be reprogrammed in a more flexible expert system that allows the questions to be asked and answered in ways that are most appropriate to the question content.
- The original model was difficult to use as a decision audit mechanism. That is, it was difficult to obtain a list of the reasons why a particular planning unit was given a particular ranking. The refined model will provide automatic decision audit in a form that is transparent to the user.
- The refined model will be verified and refined through trial runs with knowledgeable users. These trial runs will serve to fine-tune the nature of the specific questions that are asked and may result in changes to the basic logical structure of the model.

The intent is to develop a regional priorities model, using flexible expert system software, that allows good decision audit procedures and provides managers with the opportunity to practice adaptive management in their decision-making processes. Walters (1986) advocates "adaptive management" because "many key management

decisions are essentially gambles, no matter how nicely we may try to package the justification." Walters (1986) suggests that we embrace, rather than ignore, the element of uncertainty in our decision-making and use it to develop "actively adaptive policies." "Actively adaptive or dual control policies seek to establish some optimum, or at least a reasonable, balance between learning and short term performance."

3.4 Watershed Assessment Model

The watershed assessment model, the core of the HAP tool, is viewed by many as being the only "necessary" component. The primary role of this model is to allow for the input of wildlife habitat considerations into the development and review of operational forestry plans. The watershed assessment model will contain submodels that assess the quality of seasonal habitats, and a submodel that assesses the quality of the spatial interspersion of those seasonal habitats. In addition, the watershed assessment portion of the HAP tool will have the capability of imposing operational forestry plans on future maps of the landscape and of evaluating the changes that will occur, potentially throughout the rotation period, as a result of those plans.

Prototype development of the watershed assessment model will consider only black-tailed deer habitat. The winter/spring deer seasonal habitat submodel currently contains an assessment of the following habitat components for each location in the watershed (Fig. 2):

- food quality and quantity (biomass);
- snow interception cover quality;
- the proximity of the location to a stand providing food and a stand providing cover; and
- the aspect and elevation of the location.

The summer/fall seasonal habitat submodel will include the same factors as above, but relative weights of the factors will be different and the cover value included will be for security and thermal cover rather than snow interception (Fig. 2).

The seasonal habitat interspersion submodel will require the following components to assess overall habitat suitability (Fig. 2):

- the seasonal habitat quality, as derived from the habitat submodels discussed above;
- the total area that provides adequate all-season habitat (resident or year-round habitat); and
- the distance between "high quality" single-season habitats.

The clear factor that operates to constrain these models is

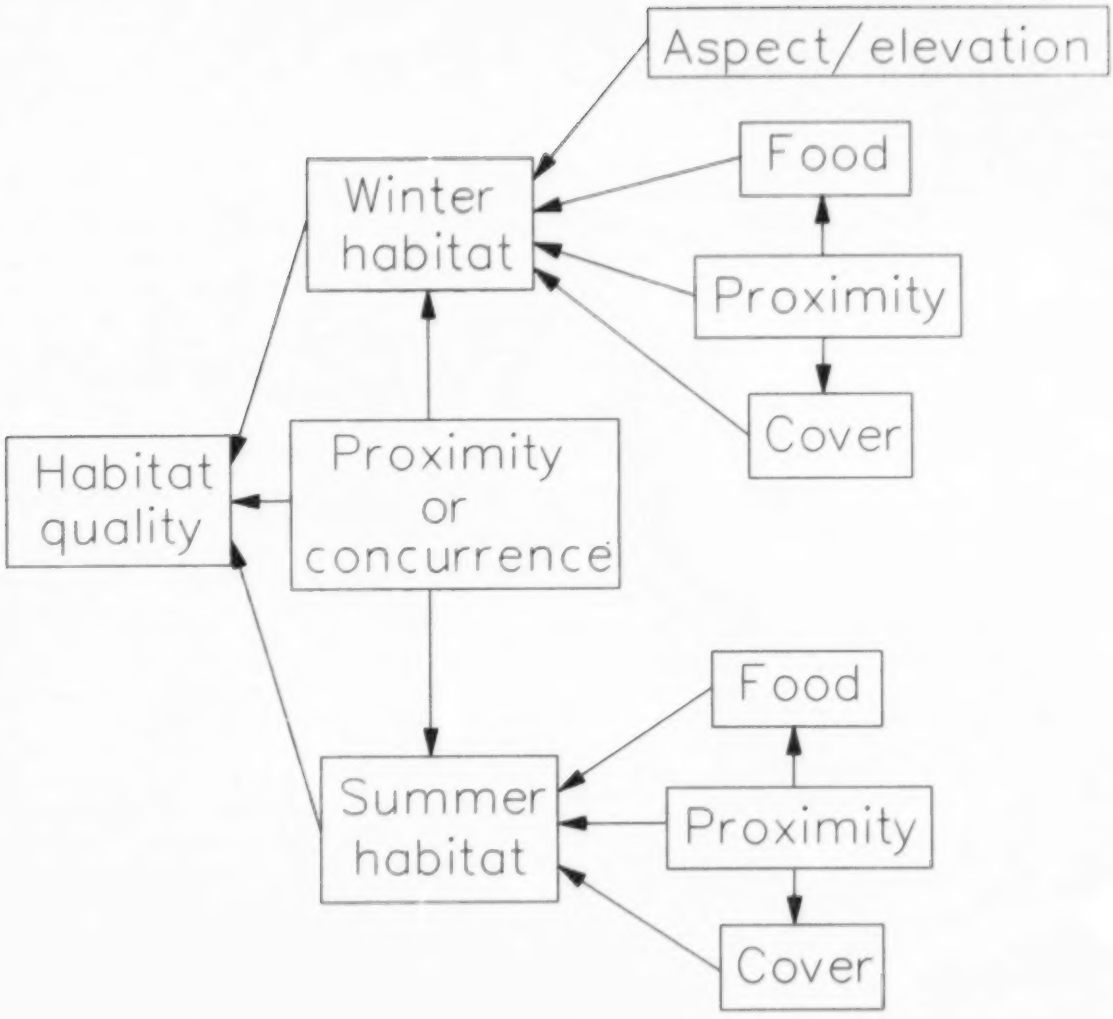

FIGURE 2. Black-tailed deer habitat quality model structure.

interspersion, the distance an animal must move between any two life requisites. On a seasonal basis, if good winter and summer habitat are available in the same area, deer can be resident and have no need to migrate. Migration, however, allows seasonal habitats to be widely dispersed and still efficiently used by the animals, but there could be constraints on how such seasonal habitats are managed (McNay et al. 1988). Within a season, the interspersion of daily requirements is important. In particular, the energetic costs of movement during winter are substantial and habitat attributes required on a daily basis must be very close together. Few habitats (stands) provide all requirements for an entire season. Even old-growth stands may not contain sufficient food to sustain deer throughout periodically severe winter weather, so some deer will preferentially establish home ranges where old-growth stands border on openings (Kremsater 1989).

Weather patterns play a crucial role in the evaluation of habitat management scenarios. Stands that provide sufficient snow interception cover in a mild winter may be poor deer habitat in severe winters. The relative frequency of mild, moderate, and severe winters in an area must be determined if the need for the various classes of snow interception cover is to be assessed. Similarly, high elevation, south slopes may become too dry to produce forage in most summers, and ungulates will favour alpine and north slope habitats. Future weather scenarios must be considered as well as future logging or successional scenarios.

These weather pattern considerations raise the problem of dealing with uncertainty in management decision-making (Hilborn 1987). There is a strong tendency for computer-generated output to be treated with unacceptably high regard for precision. Inaccurate initial data can propagate and compound errors dramatically, particularly with projections into the distant future. The usual solution is to try to increase the precision of the original data sources ignoring the fact that marginal increases in the precision of individual data sources will have little impact on the precision of the final output. There are much better ways of dealing with uncertainty than to believe we have the "best" data possible.

One method is to push the "envelope" of the design. In other words, intentionally bias the scenario being assessed in one direction and consider the effect on the final management outcome. This could be to assume a 20% increase in rate of harvest (knowing that 10% is the maximum permissible). How much difference will it make? What if an area that has experienced fairly mild winters suddenly encounters a series of much greater snowfalls, as

inevitably will happen[2]. What impact will drier summers from the greenhouse effect have on summer forage production? The best modelling outputs will likely be based on ecosystematic association (and successional stage) mapping. Aspect and elevation maps that will initially be used will be based on visual interpretation of 1:20 000 topographic maps. They have proven adequate at the resolution necessary for planning exercises. In the near future, digital terrain models from satellite images will also be available. These are relatively high quality data that will have been ground-truthed with considerable intensity. Assessments will be made of the impact on model output of the loss of information associated with less accurate and less reliable sources of data (like forest cover maps), and conversely, of the increase in information that may result from high quality data sources such as digital terrain models.

Some answers are already known. Elevation classes of 200 m are sufficiently precise for modelling deer habitat suitability. Forest cover will not provide sufficient indications of understorey forage production. Understorey may be inferred from other relationships (such as forest cover, soil type, aspect and site history), but the models will be used to direct sampling effort to the relatively few stands where such data are needed. Rather than mapping the entire area for a precise attribute like forage, the information can be collected and input only when needed. The elapsed time for an evaluation will obviously be lengthened, but this is an extremely efficient way of collecting data.

These concepts are components of an "adaptive management" scheme (Walters 1986). By trying various scenarios, in the real world and on the computer, documenting the assumptions and reasons behind the decision, and following up to evaluate success and failure, we can gain knowledge most rapidly.

3.5 Management Options Model

The main function of the watershed assessment model is to evaluate the impact of proposed scenarios on regional priorities for the area. In the management options model, the utility and likely success of various options available to the habitat manager will be evaluated. These options would include the strategies that would not ordinarily be considered for strictly silvicultural or timber management reasons (such as forage plantings, thinning below commercial levels, and prescribed burns for spring forage). Timber management options (such as extended rotations or smaller cutblocks) are best manipulated outside the HAP tool and the

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[2] Page, R.E. 1990. Predictable cyclic patterns in snowfall on Vancouver Island. B.C. Min. For., Re. Branch, Victoria, B.C. In preparation.

impacts on habitat evaluated by the watershed assessment model. The tradeoffs between timber value and deer habitat value will not be directly defined.

Not all possible options can be evaluated. For many options there will be a lack of information on likely costs, and in most cases, information on likely benefits to wildlife. A potential surrogate, which will be avoided if better methods can be devised, is to define break-even points: for example, spring forage plantings must cost less than $233/ha and benefit 51 deer. More likely the model will output relative benefits: for example, a specified amount of money will benefit more deer if Option A is applied in Area 1 than if Option B is applied in Area 2.

The difficulty in choosing the "optimal" options, rather than evaluating the scenarios provided, is the very large number of interactions between site-specific needs and seasons. For example, it may be that a lack of winter range in Area 1 can be alleviated by the provision of better fall range in Area 2, so that migrators arrive in better condition. The number of such possible interactions exceeds current computing capabilities, but is manageable within the human mind. Once the manager decides that a possible management intervention is worth considering, the power of GIS and this model can be used to evaluate the possible habitat benefits.

An obvious constraint on this model is that we will only be able to include those options for which we have sufficient information and reliable understanding. It would be unwise to include risky options that could misdirect habitat enhancement efforts because of faulty economic analysis.

The foregoing considerations indicate that this model may be relatively weak in the version that will be delivered at the end of the HAP tool development project. The utility of many habitat enhancement options will only be demonstrated and evaluated after many years and trials. The focus in this section will be a demonstration of how to evaluate options, and less on definitive recommendations to managers, unless those recommendations can be made reliable, both in terms of costs and benefits. An adaptive management scheme to evaluate continuously the utility of this model is clearly required.

4 WORKING PLAN

4.1 General Rationale and Strategy

The process of developing and implementing the HAP tool will be driven by a number of factors described below:

1. Prior to the initiation of the HAP tool development project, in January 1989, a substantial amount of preparatory work was done (McNay et al. 1987; McNay and Page 1988). It is logical to continue building on that preparatory work.

2. There are several other research projects currently under way from which the HAP tool development project can directly benefit (a handbook for managing deer and elk habitats [Nyberg and Janz 1989]; field research on the ecology of deer movement patterns [McNay and Morgan 1989]; elk habitat relationship model validation[3], a simulation model for managing stands as deer winter range [Bunnell et al. 1989]; and various integrated resource management initiatives). It is therefore reasonable to schedule the development and implementation of the project to coincide with the completions of these other activities.

3. The HAP tool development project has a deadline of March 31, 1991 when the umbrella project (IWIFR) will come to an end. Therefore, the tool development and implementation must be scheduled so that a deliverable product is available at the end of the IWIFR project and so that the post-IWIFR tasks can be justified as being outside of the terms of reference of the HAP tool development project.

4. The HAP tool currently being developed is viewed as a prototype of a more generally applicable tool that could be used for any wildlife species in any geographical area. In addition, the HAP tool will support what are essentially adaptive management activities. The tool development, implementation, verification, and refinement are therefore viewed as ongoing processes that will continue as long as the tool continues to demonstrate its utility.

The following discussion of development and implementation represents a compromise between the factors discussed above and the structured approach to systems planning and development advocated by Calkins (1984) and Stock (1988).

Stock (1988) advocates the development of a prototype early

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[3] Brunt, K. 1988. Validation of a habitat suitability model for Vancouver Island Roosevelt elk. B.C. Min. Environ., Fish and Wildl. Sect., Nanaimo, B.C. Unpub. report.

in the development of complex computerized decision support systems. The prototype serves two purposes. First, it can be used to demonstrate the utility of the overall system early in the development process, and thus can gain the support and acceptance from users and managers who might be sceptical about the eventual success of the system. Secondly, if the development of the system fails, for whatever reason, the prototype should represent a useable product that can justify the system development cost. Since the watershed assessment model forms the core of the HAP tool, this model will be used as the prototype. It will be developed for black-tailed deer because of the preparatory work done on this model prior to the initiation of the HAP tool development project. Prototype development will involve the development of seasonal range suitability models and the seasonal range juxtaposition model. Model parameters will be validated, where possible, using existing data. Some data required for the validation of model parameters is being collected by a separate research project (McNay and Morgan 1989). The model output (habitat quality) will be validated by comparing home range data with the habitat quality ratings. Completion of the development of the prototype models is expected by December 1989. Complete validation of the model will not be complete until March 1991.

Development and implementation of the full HAP tool will require:

- refinement and validation of an elk habitat relationship model;
- refinement of the regional priorities model;
- development of the components of the management options model;
- extension and technical transfer of the completed tool; and
- testing of the reliability and validity of the overall tool output.

The strategy for completion of these tasks is briefly described below.

An elk habitat quality model (Brunt and Ray 1986) is currently being validated by a separate research project[3]. This model will be modified to fit within the watershed assessment model framework. Once this is done, the HAP terms of reference regarding species habitat relationship models will be complete. Automation of the elk model may be completed as early as March 1990. However, refinement and validation of the model will not be complete until March 1991.

The prototype regional priorities model developed by McNay and Page (1988) will be improved based on the process outlined in section 3.3. It is anticipated that this task will be completed after the development of the watershed assessment models (April 1990 to March 1991). An assessment of the validity of the regional priorities model will require many years because of the nature of

the model output (see below). The components of the management options models are being developed largely by other research projects (Bunnell et al. 1989; Nyberg and Janz 1989). These components will be incorporated into the HAP framework as they become available. However, site-specific planning is seen to be a secondary consideration of the HAP tool development project, and so the management options model will probably not be completed until after March 1991 (the deadline for completion of HAP).

Delivering an operational tool that will be used will require that the prospective users accept the utility of the tool and have the ability to use it. Therefore, extension and technical transfer of the HAP tool will involve a two step process. The first step will be to demonstrate the utility of the tool to the middle management personnel within the Habitat Protection Section of MOE. This will be done by assisting these personnel with the application of the watershed assessment model to a particularly difficult or high conflict problem they are encountering. The same personnel will be assisted with the operation of the regional priorities tool to assess broad scale priorities throughout their entire region.

Training the "line" personnel in the use of the tool will be a time-consuming process. It will require specialized skills to create the users' manuals and training courses, and to deliver the courses. Extension of the tool will also require the acquisition of computer hardware and software for the line personnel. Managers must be aware that the process of extension and training will be time-consuming and costly and will probably result in a decrease in productivity in the short term. Because of the short time frame for the completion of the HAP tool, and the time-consuming nature of training line personnel, such training may begin during IWIFR but will not be completed until well after the IWIFR project has ended. It is anticipated that extension and training of the HAP tool will be completed by September 1992 (see Section 4.3).

Two other elements critical to the successful operation of the HAP tool are beyond the capabilities of the HAP team to develop because of the manpower and time limitations. These elements are:

1. a microcomputer-based forest succession model that can be used to progress forest cover and/or ecosystematic association maps through time; and
2. sub-models developed for the management options models.

There is some indication that both of these problems are being addressed by other groups within and outside the public service (e.g. Managed Stands for Deer Winter Range [Bunnell et al. 1989] and several planning initiatives within the Integrated Resources Branch and the Research Branch of the Forest Service). As the HAP tool development project progresses, a detailed approach to incorporating these elements, in whatever form they arise, will be developed.

Testing the reliability and validity of the tool's output will be an ongoing process. Management recommendations will be made based on the tool output and it will take many years in some cases to determine whether or not those recommendations were correct. For this reason a major emphasis in the tool construction will be placed on good decision audit mechanisms. For example, the watershed assessment model will have the ability to maintain a data base of all the information about a given cutblock in a forestry plan, including field reconnaissance information, in-house discussions and recommendations, and letters sent to the forestry company or MOF. This data base will be useful in day-to-day operations for reviewing updated versions of plans and preparing Ministry referrals. It will also be useful to the future assessment of the utility of recommendations based on the model output.

4.2 Task Specification

The following section briefly describes the tasks required to complete the development of the HAP tool. The tasks are listed in a logical order of requirement for the tool rather than in the order in which they will be completed. Scheduling and manpower requirements are discussed in Section 4.3. The level of detail in the task specification varies primarily on how soon the task will be completed.

4.2.1 Develop a watershed assessment model for black-tailed deer

Completion of this task will result in an operational watershed assessment model for black-tailed deer.

A. Complete the winter habitat suitability model:

i. Complete parameter estimation for all ecosystematic associations in the Nanaimo River Camp study area.
ii. Apply completed model to the entire Nanaimo River Camp study area.
iii. Validate parameter estimates for food, cover, and aspect/elevation quality using statistical analysis of existing data.
iv. Validate model output using home range overlay analysis.

B. Develop the summer habitat suitability model:

i. Develop model structure.
ii. Estimate model parameters.
iii. Apply model to the Nanaimo River Camp study area.
iv. Validate model parameters, including collection of summer food quality data as necessary.
v. Validate model output using home range overlay analysis.

C. Develop the seasonal range juxtaposition model:

i. Develop model structure.
ii. Estimate model parameters.
iii. Apply model to the Nanaimo River Camp study area.
iv. Validate model parameters using the data being collected by the IWIFR deer project.
v. Validate model output using the Delphi approach or some other suitable expert opinion-based approach.

D. Assess the utility of forest cover data to replace ecosystematic association data:

i. Obtain digitized forest cover maps from MacMillian-Blodel Company and convert them to Pamap format.
ii. Overlay forest cover on ecosystematic association to determine the level of correspondence between the two data sources.
iii. Modify model parameters to correspond to the forest cover types.
iv. Apply model to the Nanaimo River Camp study area.
v. Validate model parameters using existing data.
vi. Validate model output using home range overlay analysis.

E. Apply the completed model to the Nanaimo River Camp study area map using an hypothetical harvesting scenario and progression of the vegetation succession through time:

i. Develop and digitize hypothetical harvesting scenario(s).
ii. Develop transition specifications for ecosystematic association/seral stage combinations and forest cover types (successional model) to effect the progression of the vegetation cover through time.
iii. Modify the map data base to incorporate the forest harvesting scenario and progression through time for a period of up to 60 years.
iv. Apply the habitat quality model at 20-year intervals and evaluate the impacts of forest harvesting and time on the habitat quality.

F. Apply the completed model to a second test area:

i. Choose best test area based on the availability of biophysical data (vegetation and topography) and deer home range data.
ii. Obtain biophysical data.
iii. Apply model.
iv. Validate model output using home range overlay analysis.

G. Develop an operational prototype watershed assessment model for black-tailed deer:

i. Develop a detailed set of specifications for decision audit procedures and outputs.
ii. Develop decision audit data bases and methods.
iii. Develop methods of automating the procedure for habitat quality assessment.
iv. Complete parameter estimation for all of Vancouver Island.

4.2.2 Develop a watershed assessment model for Roosevelt elk

The HAP tool development project team will rely substantially on the efforts of the IWIFR Elk project to develop, test and deliver a habitat quality model that will form the core of the watershed assessment model for elk.

A. Develop a habitat quality model for Roosevelt elk:

i. Assist IWIFR elk project team in their efforts to develop an operational habitat quality model for Roosevelt elk that will be applicable to the HAP tool.
ii. Obtain operational model and modify it, as required, to "fit" the HAP framework.
iii. Validate model output with the assistance of IWIFR elk project team.

B. Develop an operational watershed assessment model for Roosevelt Elk:

i. Modify decision audit procedures and outputs developed for black-tailed deer, as required, to make them applicable to Roosevelt elk.
ii. Modify methods of automating the procedure for habitat quality assessment developed for black-tailed deer, as required, to make them applicable to Roosevelt elk.
iii. Complete parameter estimation for the elk model for all of Vancouver Island.

4.2.3 Develop an operational regional priorities model for black-tailed deer and Roosevelt elk

Development of the regional priorities model will principally require modification of the existing prototype and the application of that prototype to a test area to determine what refinements to the model are required.

i. Reassess and modify prototype model structure developed by McNay et al. (1987) to include current perceptions about regional priorities for black-tailed deer and Roosevelt elk.

ii. Reassess prototype model parameters as above.
iii. Reprogram model using a flexible expert system shell to include the reassessment undertaken above and to include the ability to provide user transparent decision audit.
iv. Cooperate with suitable Regional Fish and Wildlife staff to apply the regional priorities model to a test area of Vancouver Island.
v. Modify expert systems model and the GIS data, as required, based on the results of the test run.

4.2.4 Develop a management options model

Development of the complete conceptual framework for the management options model (task A. below) will be completed within the IWIFR time frame. Development of an operational management options model will not be possible until after IWIFR is over because of the schedules of related projects and because of the time and manpower/budget limitations on the HAP tool development project itself.

A. Develop a complete conceptual framework for the management options model:

i. Specify required outputs of the model.
ii. Specify model components (sub-models, rules, data, etc.).
iii. Define relationships among the model components and specify the way in which the model will operate.
iv. Define model inputs.

B. Develop an operational management options model:

i. Obtain available sub-models, rules, data, etc.
ii. Modify models and/or rules as required to fit conceptual framework.
iii. Compile expert opinion to fill information and understanding gaps.
iv. Combine models and information into an operational management options model.

4.2.5 Extension and Technical Transfer of the HAP Tool

Fostering acceptance of the HAP tool (task A below) and the development of a strategy for technical transfer of the HAP tool will be completed within the IWIFR time frame. Implementing the strategy for technical transfer will have to be done after the completion of IWIFR because of the of the time and manpower/budget limitations on the HAP tool development project.

A. Foster acceptance of the HAP tool among middle management staff in the Nanaimo and Surrey Regional Offices:

i. Apply the watershed assessment model (black-tailed deer) to a particularly difficult or high conflict problem in the Regional office:
   a) Specify problem and choice of area.
   b) Assemble biophysical data.
   c) Develop transition specifications for ecosystematic association/seral stage combinations and/or forest cover types (successional model) to effect the progression of the vegetation cover through time.
   d) Modify map data base to incorporate the forest harvesting scenario and progression through time for a period of up to 60 years.
   e) Apply watershed assessment model.
   f) Assess the quality and utility of the results.

ii. Apply the regional priorities model to the current area of concern on Vancouver Island.

B. Develop a strategy for technical transfer of the tool:

i. Specify user manual requirements.
ii. Specify hardware and software requirements.
iii. Specify training requirements.
iv. Specify time and manpower requirements both during and after the technical transfer stage.
v. Specify the requirements for changes in the day-to-day operations of the Ministries of Environment and Forests and the forestry companies that will be required to effect technical transfer of the tool.
vi. Develop a schedule for technical transfer of the HAP tool to users in the Ministries of Environment and Forests and the forestry companies.

C. Implement the technical transfer strategy:

i. Obtain commitment from ministry and corporate executives to: budget for system acquisition; accept the short-term loss in productivity that will result from transferring the HAP tool; and change day-to-day operations to incorporate the requirements of the HAP tool.

ii. Develop users' manuals, system specifications and training programs.
iii. Acquire systems and implement training programs.

4.2.6 Communications plan for the HAP tool development project

The following list of communications tasks is not meant to be limiting. Other papers and symposia or workshops may be included as the need arises. Liaison with individual and agencies interested in the development of the HAP tool will be an ongoing task which is not included with those specified below.

A. In-house (IWIFR) reports, including:

i. monthly Progress Reports sent to members of the IWIFR Technical Working Group and other interested parties;
ii. an Annual Progress Report and working plan update outlining progress, problems, and potential and changes to the working plan resulting from the progress made; and
iii. a Job Completion Report outlining objectives, methods, results and a discussion of the utility and future of the HAP tool.

B. Journal articles, including:

i. a popular journal article on the use of emerging computer technology in the field of integrated forestry and wildlife management (e.g., Nature Canada, Equinox);
ii. a scientific journal article directed at GIS or expert systems practioners (e.g., Photogrammetric Engineering and Remote Sensing, Artificial Intelligence Applications); and
iii. a scientific journal article directed at forestry and wildlife managers (e.g., Wildlife Society Bulletin, Transaction of the North American Wildlife and Natural Resources Conference).

C. Symposia, conferences, and workshops

i. the Habitat Futures 1989 workshop (Pack National Forest, Washington).
ii. the GIS '90 symposium (Vancouver).
iii. a HAP tool development project review workshop to be attended by the IWIFR Technical Working Group and other interested parties early in the 1990/91 fiscal year.

4.3 Scheduling and Manpower Requirements

Table 1 shows a summary of manpower requirements for the HAP tool development project by participant and fiscal year. We are unable to specify the names of contractors at this time because there are outstanding proposals to obtain manpower for the HAP tool development project. These include joint proposals with the IWIFR deer and elk projects for money from the South Morseby Replacement Fund and the Environmental Youth Corp. Manpower requirements from the Regional Fish and Wildlife staff involve primarily assistance with evaluation of HAP outputs. In the 1990/91 fiscal year we are requesting a relatively large commitment from Regional Fish and Wildlife staff to assist with the application of the watershed assessment model to an area of high conflict or concern. Assistance from the Forest Service includes help with the definition of forest succession relationships, the development of the management options model, and the development of a training program for HAP. Table 2 specifies the manpower requirements and completion dates by task and sub-task as identified in Section 4.2.

TABLE 1. Manpower requirements for the HAP tool development project summarized by participant and fiscal year

	Man-days by fiscal year	
Participant	1989/90	1990/91
Marvin Eng	124	177
R. Scott McNay	16	8
Rick Page	24	15
Contractor	98	33
Reg. Fish and Wildlife Staff	4	37
Forest Service Staff	6	14
TOTALS	272	284

TABLE 2. Scheduling and manpower requirements for the HAP tool development project by "activity" and task

Activity	Task	Date[a]	Man-days by participant ME[b]	SM[c]	RP[d]	CN[e]	FW[f]	FS[g]
Develop Prototype Watershed Assessment Model for Black-tailed Deer								
A.	Complete the winter habitat suitability model:							
i.	parameter estimation	6 89	1	1				
ii.	apply model to NRC	6 89	5					
iii.	validate food rating	8 89	2			10		
iii.	validate cover rating	8 89	2			5		
iii.	validate asp/elev rating	8 89	2			15		
iv.	validate output	9 89	5		5	25		
B.	Develop the summer habitat suitability model:							
i.	develop model structure	7 89	2		3			
ii.	estimate parameters	7 89	1	1				
iii.	apply model to NRC	7 89	4					
iv.	collect data for valid.	8 89	4			10		
iv.	validate parameters	9 89	2			2		
v.	validate output	9 89	3			10		
C.	Develop the seasonal range juxtaposition model:							
i.	develop model structure	7 89	1		1			
ii.	estimate parameters	7 89	1	1				
iii.	apply model to NRC	7 89	3					
iv.	validate parameters	3 91	5	3				
v.	validate output	12 90	5				2	
D.	Assess the utility of forest cover data:							
i.	obtain maps	7 89	2			1		
ii.	overlay and compare	8 89	3	1				1
iii.	modify parameters	8 89	1	2				
iv.	apply model to NRC	9 89	5					
v.	validate parameters	8 89	3			15		
vi.	validate model output	9 89	3			5		
E.	Apply the completed model to Nanaimo River Camp study area:							
i.	harvest scenario	10 89	5		1			
ii.	successional model	10 89	5					2
iii.	modify BEC map	10 89	2					
iv.	apply model & evaluate	10 89	6				2	

TABLE 2. (Continued)

Activity	Task	Date[a]	ME[b]	SM[c]	RP[d]	CN[e]	FW[f]	FS[g]
				Man-days by participant				
F.	Apply the completed model to a second test area:							
i.	select area	7	89	1	1			
ii.	obtain data	4	90	5		10		
iii.	apply model	4	90	5				
iv.	validate output	5	90	3		3		
G.	Develop an operational prototype watershed assessment model:							
i.	develop specs	1	90	3			2	
ii.	develop data bases	1	90	1				
iii.	develop automation	4	90	5		5		
iv.	complete parameter est.	3	90	1	3			3
Develop a Watershed Assessment Model for Roosevelt Elk								
A.	Develop a habitat quality model for Roosevelt elk:							
i.	assist K. Brunt	8	89	3				
ii.	modify model	2	90	5		5		
iii.	validate model	3	91	5			5	
B.	Develop an operational watershed assessment model:							
i.	modify decision audit	3	90	2				
ii.	modify automation	4	90	5				
iii.	complete parameter est.	4	90	1			5	
Develop an Operational Regional Priorities Model								
i.	reassess model structure	5	90	5			2	
ii.	reassess model param.	5	90	5			2	
iii.	reprogram model	6	90	15		3		
iv.	apply to test area	7	90	1			2	
v.	modify model from test	7	90	3				
Develop a Management Options Model								
A.	Develop conceptual framework for the management options model:							
i.	specify outputs	9	90	3		1		
ii.	specify model components	9	90	3				2
iii.	define relationships	10	90	3		1		2
iv.	define inputs	10	90	1				

TABLE 2. (Continued)

Activity	Task	Date[a]	Man-days by participant ME[b]	SM[c]	RP[d]	CN[e]	FW[f]	FS[g]
B.	Develop an operational management options model:							
	i. obtain submodels	6 91						
	ii. modify submodels	8 91						
	iii. fill gaps	9 91						
	iv. develop operational	12 91						
Extension and Technical Transfer of the HAP Tool								
A.	Foster acceptance of the HAP tool among middle management							
	i(a). area selection	4 90		1			2	
	i(b). assemble biophys data	8 90		5		15		
	i(c). forest succ & harvest	8 90		5				5
	i(d). apply model	9 90		10			5	
	i(e). evaluate results	9 90		3			5	
	ii. apply reg. priorities	11 90		5			5	
B.	Develop a strategy for technical transfer of the tool:							
	i. manual requirements	10 90		2				
	ii. hard/software require	10 90		1				
	iii. training requirements	10 90		3				5
	iv. time & manpower	10 90		2				
	v. change to operations	10 90		2			2	
	vi. schedule for transfer	10 90		3				
C.	Implement the technical transfer strategy:							
	i. obtain exec. commit.	4 91						
	ii. develop manuals/training	9 91						
	iii. implement transfer	9 92						

TABLE 2. (Completed)

Activity	Task	Date[a]	ME[b]	SM[c]	RP[d]	CN[e]	FW[f]	FS[g]
			Man-days by participant					
Communications Plan for the HAP Tool Development Project								
A.	In house (IWIFR) reports:							
	i. progress	3 91	12					
	ii. annual progress	3 90	10	3		2		
	iii. job completion	3 91	10	3		2		
B.	Journal articles:							
	i. popular journal	12 89	10			2		
	ii. scientific GIS	6 90	10			3		
	iii. scientific wildl.	12 90	10			3		
C.	Symposia, conferences, and workshops							
	i. Habitat Futures	10 89	15	3		5		
	ii. GIS '90 Symposium	3 90	15	3		5		
	iii. HAP workshop	7 90	15	2		2		

[a] Proposed completion date.
[b] Marvin Eng.
[c] Scott McNay.
[d] Rick Page.
[e] Outside contractor.
[f] Regional Fish and Wildlife staff.
[g] Forest Service staff.

4.4 Budgetary Requirements

At the May 3-4, 1989, IWIFR Technical Working Group meeting, the HAP tool development project was allocated an operating budget of $14 700 for the 1989/90 fiscal year. The schedule and manpower requirements (Table 2) were developed to disburse this budget in the most efficient manner. A summary of proposed budget allocation by task and Standard Object of Expenditure is presented in Table 3.

TABLE 3. Summary of proposed budget allocation for the 1989/90 fiscal year by task and Standard Object of expenditure.

Activity	Expenditure ($) by standard object			
	Travel (10)[a]	Vehicle (50)	Contract (20)	Equip (50)
Prototype development	570	605	10 800	700
Communications	595	255		200
Field orientation[b]	425	550		
TOTALS	1 590	1 410	10 800	900
			GRAND TOTAL	14 700

[a] Standard object of expenditure code.

[b] Task not specified in Section 4.2. Field orientation is required for Marvin Eng so that he can gain insight into the real world components of the HAP tool and to ensure that he establishes credibility with other researchers and managers.

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